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Monetary policy and time varying parameter vector autoregression model

Andreea Roşoiu[a,*]

[a]The Bucharest University of Economic Studies, 6, Piata Romana, 1st District, Bucharest, postal code:010374, Romania

Abstract

The aim of this paper is to present an estimation about the evolution of the monetary policy transmission mechanism in Romania over a specific period of time, by using a time-varying vector autoregression model. Impulse responses to a monetary policy shock are computed and sign restrictions are used in order to identify a monetary policy shock. The assumption that is being used as a starting point is that a monetary policy shock is the one that leads to an increase of the interest rates and in the same time to a decrease in inflation and output growth. The aim of this study is to observe whether the impulse response functions show evidence of significant variation across time. The importance of analyzing this phenomenon comes from the importance of ensuring price stability as long as sustainable economic growth for Central Banks.

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1. Introduction

The purpose of this paper is to analyze the influence that a shock in the monetary policy interest has over the Romanian economy, more precisely the impact on macroeconomic variables such as inflation and unemployment rate especially since the strategy adopted by the National Bank of Romania in 2005th is inflation rate targeting without neglecting the sustainable economic growth. This analysis is not a static one, the evolution of the macroeconomic variables is investigated in time, starting with 2000 up until 2014.

Andreea Roşoiu. Tel.: +40-723-656-419.
E-mail address: andreea.rosoiu@yahoo.com.

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The paper is structured as follows: the first section which is entitled *The Empirical Model* is providing details about the estimation methodology, more precisely time varying vector autoregressive modes and Bayesian inference and it is also providing a short description of the steps that should be followed in order to do the estimation. The next section, *Empirical Evidence* is offering information about the sample of the time series that are used in order to do the analysis and corresponding transformations and it is also describing the results of the estimation. The paper ends with a final section where both conclusions and suggestions for further research are outlined.

2. The Empirical Model

2.1. Vector autoregressive models and Bayesian inference

The structural vector autoregressive (SVAR) approach has been largely used since it was initially implemented by Bernanke and Blinder, 1992 or Sims, 1992 in order to estimate the transmission of the monetary policy. This frequent usage is based on the advantages brought by this method. One of these advantages is the minimum amount of restrictions that need to be imposed in order to identify the source of variation in a monetary policy transmission mechanism. Despite this, the system of equations allows the user to capture only the relevant macroeconomic dynamics. On the other hand, this approach proved to be less effective in uncovering the transmission mechanism of monetary for small open economies.

In order to be able to measure policy changes, time varying parameters should be used. In order to understand the impact of the changes in policy on the rest of the economy, a model with multiple equations is needed. Therefore, these two instruments contribute to the formation of a time varying structural vector autoregression model with the source of time variation deriving from drifting coefficients.

Primiceri, 2005 is estimating in his paper a time varying structural vector autoregression model where the source of time variation comes from both the variance-covariance matrix and from the coefficients. The analysis that he conducted is on the United States systematic and non-systematic monetary policy and the conclusion is that there is evidence regarding the existence of time-variation for this economy.

Benes, 2014 is describing the way IRIS toolbox could be used in order to identify structural vector autoregression models based on sign restrictions, in Matlab. Not just sign restrictions for the first period are imposed, but also the sum of responses over a user specified period of time is restricted. The focus in this paper is not necessarily on the economic mechanism, but instead on the more technical part related to the implementation and estimation of the model.

Blake and Mumtaz, 2012 are also describing the way this type of model can be implemented in Matlab. The difference is that the impulse response functions are estimated for each moment in time over the length of the sample, therefore an easier comparison regarding the evolution of these responses in time can be done.

In this paper a time varying parameter VAR model with sign restriction is estimated and the source of variation is coming only from the coefficients. Bayesian methods are used with the purpose of estimating the posterior distributions of the parameters of interest, more precisely, Gibbs sampling algorithm and Kalman smoother. Classical maximum likelihood estimator is replaced by Bayesian methods due to several drawbacks, which were also outlined by Koop and Korobilis, 2009:

- High dimensionality and nonlinearity are difficult to be dealt with;
- The maximum likelihood function is difficult to compute and to maximize over such a high dimensional space;
- Once the user manages to maximize the likelihood function, multiple local maximum points could be derived and not a single global maximum point ;

- Due to these peaks, the likelihood might reach high values but these values could be misleading if they are to be used as an argument for the quality of the model.
- When unobservable components are to be estimated and the model is non-linear, Bayesian methods are recommended to be used.

Kalman smoother is also a part of the algorithm, which means that not just the observations up to the precise moment in time when the estimation is being done are used. Instead the entire available sample of data is considered.

2.2. Short description of the model

The following VAR model with time-varying coefficients which is also described by Blake and Mumtaz, 2012, is considered:

$$Y_t = c_t + \sum_{j=1}^{P} B_{j,t} * Y_{t-j} + \vartheta_t, VAR(\vartheta_t) = R \quad (1)$$

$$\beta_t = \{c_t, B_{1,t}, \dots, B_{P,t}\} \quad (2)$$

$$\beta_t = \mu + F * \beta_{t-1} + e_t, VAR(e_t) = Q \quad (3)$$

With the following specifications:

- Y_t stands for a $T \times 1$ matrix containing the dependent variables;
- $\beta_t$stands for the unobserved component or the state variables;
- ϑ_t and e_t are the error terms;
- j is the number of lags and it can vary between 1 and P;
- μ is an intercept;
- $F$is a matrix of coefficients.

The assumption that is considered in this paper is similar to Andrew Blake and Haroon Mumtaz (2012): μ=0 and F=1. The posterior distribution of R conditional on the time-varying coefficients β_t(which are assumed to be known) is inverse Wishart distributed. Q is also inverse Wishart distributed, conditional on β_t. And conditional on R and Q and considering that μ=0 and F=1, the model is a linear Gaussian state space model. The conditional posterior of β_t is evolving as a normal distribution.

Gibbs Sampling algorithm is applied and it consists in looping the following steps:

<u>Step1</u>: Set a prior for Q which is inverse Wishart. It is usually set starting from a training sample and this is the procedure applied for this estimation. Due to the fact that this prior influences the amount of time-variation, a scaling factor is used. This number is seen as a coefficient of adjustment for the length of the training sample which is a small one, hence the possibility that the starting values used to initialize the priors to be imprecise. A prior is also set for R matrix.

$$p(Q) \sim IW(Q_0, T_0) \quad (4)$$

WhereT_0 is the number of observations in the training sample and:

$$Q_0 = p_{0\backslash 0} \times T_0 \times \tau \quad (5)$$

$\tau$is the scaling factor set by the user and

$$p_{0\backslash 0} = \Sigma_0 \otimes (X'_{0t} X_{0t})^{-1} \quad (6)$$

Where $X_{0t} = \{Y_{0t-1}, \dots, Y_{0t-p}, 1\}$
and:

$$\Sigma_0 = \frac{(Y_{0t} - X_{0t} * \beta_0)'(Y_{0t} - X_{0t} * \beta_0)}{T_0 - K} \tag{7}$$

with the superscript *0* denoting the fact the it represents the training sample.

Step 2.$\tilde{\beta}_t$is sampled afterwards conditional on R and Q.After estimating $\tilde{\beta}_t$, a check for stability of the model is also done and if the stability condition is false for a specific period in time, the resulted matrix is discarded and the algorithm will do the step again.

Step 3.Q is estimated considering its own conditional posterior distribution function.

Step 4.R is also estimated considering its own conditional posterior distribution function.

Step 5.Steps from two to four are repeated afterwards and the last number of draws is saved for inference.

Step 6.Finally, the impulse response functions to a shock in a certain variable are computed, by using the sign restrictions according the economic theory.

3. Empirical Evidence

3.1. Purpose

A VAR model with time varying parameter is estimated for the Romanian economy and using the following sample of data: the harmonized index of consumer prices used a proxy for inflation and three-months money market interest rate used as a proxy for monetary policy interest rate (due the availability of the observations), and unemployment rate, over the period 1997:M1-2014:M7. This model is used in order to compute impulse response functions after a shock in interest rate for each moment in time and check whether the response of the macroeconomic variables changed over the time. The assumptions that are considered and are translated into sign restrictions are the following ones: a monetary policy shock leads to a decrease in the level of inflation, an increase in the unemployment and an increase in the level of interest rates.

3.2. Data and transformation

The time-varying parameter VAR model is estimated by using a sample of Romanian macroeconomic time series, more precisely the harmonized index for consumer prices as proxy for interest rate, the unemployment rate and the three-month money market interest rate as a proxy for monetary policy interest rate. The frequency of the data is monthly, the period covers 2000:M1-2014:M7. The harmonized index of consumer prices is used in logarithm. The initial sample of 45 observations is used as a training sample in order to initialize the priors and a number of two lags is used for estimating the model. The number of lags is not set to a larger value due to the fact that there are only 175 observations available for each time series out of which the first 45 are discarded. The algorithm consists in looping 101000 runs out of which the first 100000 are discarded for convergence reasons. These time series are downloaded from Eurostat and they were not seasonally adjusted initially.

Seasonal adjustment is applied afterwards, by using Demetra+ software with TRAMO/SEATS method and RSA4 specification. The data is also checked for the existence of unit roots by using the Augmented Dickey-Fuller (ADF test) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS test). Both tests are doing the same evaluation over the sample data, the difference between them being the one that while the null hypothesis for the ADF test is that of a unit root, the null hypothesis for the KPSS test is that of a stationary process.

3.3. Impulse response functions

In *Figure 1* the evolution of inflation rate due to a change in monetary policy the interest rate level is estimated for a horizon of 15 months and for each moment in time starting with 2003:M10 and ending with 2014:M7. After a change in monetary policy interest it is expected for inflation rate to decrease – investors have higher financing costs, therefore investments become less attractive at a higher interest rate level, consumption is also reduces in favour of savings, with an ultimate impact on gross domestic product or demand. A lower level of the output translates into a decrease in inflation.

If the evolution in time of the responses is to be considered, it can be seen that there is not much change between impulse responses functions for the above mentioned period. It can be also noticed that, the impact of a change in monetary policy interest rate over inflation dissipates in time, therefore the level of inflation turns back to its starting value. This statement comes as a confirmation for the fact that monetary policy interest rate is not an instrument that can be used to stimulate the economy on the long run.

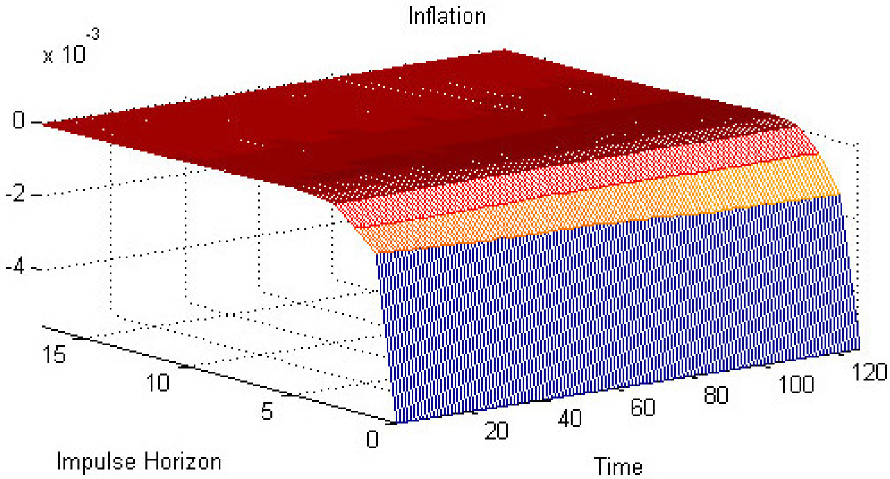

Fig. 1.Impulse response function of inflation rate due to a change in the level of the monetary policy interest rate,for 15 months and in each moment in time from 2003:M10 up until 2014:M7 (Time axis)

The evolution of unemployment rate after a shock in interest rate is plotted in *Figure 2*. The horizon that is considered is also equal to 15 months and the results are estimated for each moment in time, starting with 2003:M10 and ending with 2014:M7. Unemployment rate increases after an increase in the level of interest rate and it stabilizes afterwards. This evolution is also according to the theoretical point of view. The reason behind this increase is given by the fact that investments become less attractive and the costs for the companies to continue with their activity are higher. A decreased level of investment translates into a reduced need for labor force. Similar to the situation shown in *Figure 1*, there is not much change between impulse responses functions when comparing different moments in time over the selected period. The impact dissipates in time too. This evolution is also confirming the fact that monetary policy cannot be used as a mechanism in order to stimulate the economic growth on the long run. Several other sources should be looked for such as investments, technology or improved productivity.

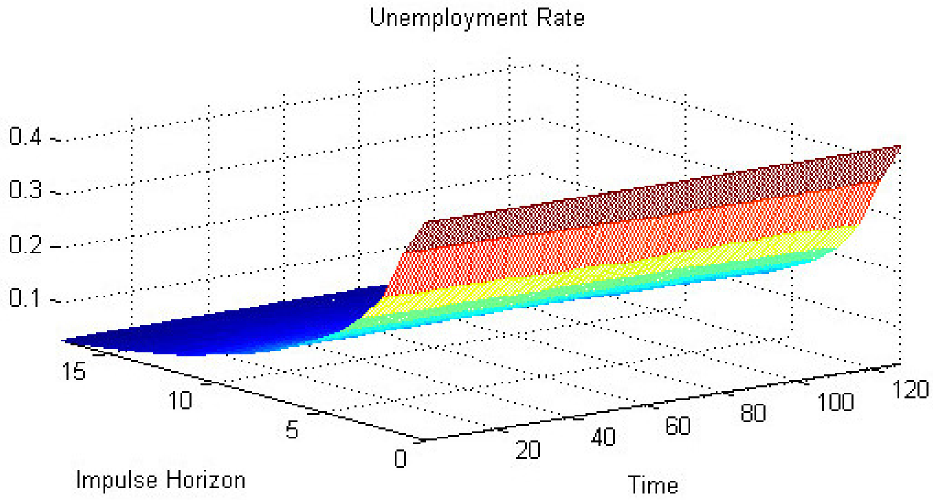

Fig. 2.Impulse response function of unemployment due to a change in the level of the monetary policy interest rate, for 15 month and in each moment in time from 2003:M10 up until 2014:M7 (Time axis)

The response of the interest rate after a change in interest rate itself is displayed in *Figure 3*. This response does not bring a significant informational gain, but what is worth mentioning is that the response is seen immediately and not with lags and it is adjusting back to the initial value over time. There is also no significant change regarding the responses from different moments in time.

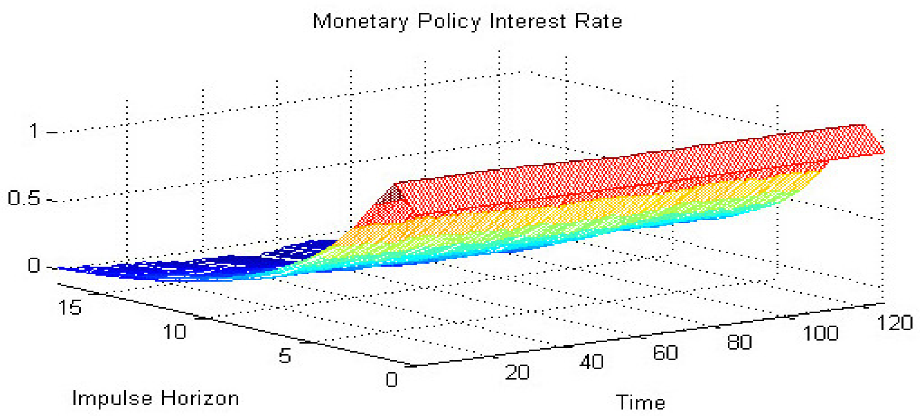

Fig. 3.Impulse response function of interest due to a change in the level of the monetary policy interest rate, for 15 months and in each moment in time from 2003:M10 up until 2014:M7 (Time axis)

4. Conclusions

The aim of this paper isto estimate the evolution of the impact of a change in the level of the monetary policy interest rateon macroeconomic variables such as inflation and unemployment rate from 2000 up until

2014, for Romanian economy. The harmonized index of consumer prices, the unemployment rate and three-month money market interest rate are the data series that were used in this monthly model. The approach that is adopted consists in a time-varying parameter vector autoregressive model with sign restrictions which is estimated by using Bayesian inference. The algorithm consists in looping 101000 runs out of which the first 100000 are discarded for convergence reasons. These evolutions are according to the theoretical view and do not show much time variation. Therefore, after a change in monetary policy interest it is expected for inflation rate to decrease due to the fact that investors have to face higher financing costs, therefore investments become less attractive at a higher interest rate level. Consumption is also reduces in favor of savings. These being components of the aggregate demand, they lead to a decrease in the aggregate demand level itself. Therefore, a lower level of the output translates into a decrease in inflation. Unemployment rate, on the other hand, increases after an increase in the level of interest rate and it stabilizes afterwards. The reason behind this increase is given by the fact that investments become less attractive and the costs for the companies to continue with their activity are higher. A decreased level of investment translates into a reduced need for labor force. It can be also noticed that, the impact of a change in monetary policy interest rate over inflation and unemployment rate dissipates in time. This statement comes as a confirmation for the fact that monetary policy interest rate is not an instrument that can be used to stimulate the real economy on the long run. The focus should be instead on higher levels of productivity, investments, innovation. For further research I would propose the estimation of an indicator/statistic for comparative analysis of the impulse responses in time and use this indicator instead of a visual interpretation. Also a comparative analysis between models that estimate the same macroeconomic phenomenon such as monetary policy transmission mechanism could be the subject of a future paper. Several other data series might be also included in the model such as inflation expectation or macroeconomic variables such as corporate/households loans/deposits.

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